round articular transplants over the involved defect. The authors have published only preliminary results of this procedure to date.

Each of the evolving techniques for cartilage transplantation has both advantages and disadvantages. It is premature to offer a dogmatic assessment of a long-term outcome from any of the newer procedures. Such assessments can only come from prospective comparative studies in large numbers of cases. There are some obvious pros and cons, however, that can be enumerated for consideration by the patient and the treating surgeon.

Allografting carries the potential of immune response, from potential viral contamination and from a delay between the time of decision for surgery and the availability of a suitable donor. Because it is necessary to size the graft to match the recipient, the delay may be more than several weeks, which can be a major problem for the patient. And, as is the case with transplantation in other organ systems, the shortage of donors for cartilage allografting is a continuous problem.

The cell culture (Carticel) procedure is challenging because of the need to submit a cartilage cell source from the patient to the cell "factory" for the safe culture of enough cells for transplantation. This is an expensive step that requires a short delay. The application of the technique with osteochondritis dissecans requires experimental and clinical confirmation.

The mosaic procedure does not provide a uniform surface area; rather, it creates a "cobblestone" pattern with gaps between the grafts. It is not clear how long this type of surface will wear effectively. The mosaic technique has a number of interface defects between each of the cylinders, so the cobblestone pattern is permanent. Furthermore, the damage to the donor area may be detrimental over the long-term.

In spite of these problems, both proven and theoretical, both the allograft and cell culture techniques offer functional improvement to the patient in a large percentage of the properly selected cases. The phrase "properly selected cases" typically refers to the restriction of traumatic defects to a single surface—or osteochondritis dissecans—in an otherwise healthy joint. There is excitement about the potential of these approaches; however, caution must be exercised and enthusiasm must be tempered with objectivity. The final outcome of necessary studies will not be available for at least a couple of decades. The need for prospective studies is obvious and must be pursued energetically. In the meantime, frank and open discussion with our patients about the merits and disadvantages of each of the approaches is mandatory. We must hope for better informed, more objective, and better balanced presentations of these approaches by the media to help keep patient expectations realistic.

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REFERENCES

Brittberg M, Lindahl A, Nilsson A, et al. Treatment of deep cartilage defects in the knee with autologous chondrocyte implantation. N Engl J Med 1994; 331:889–895

Czotrom AA, Keating S, Gross AE. The viability of articular cartilage in fresh osteochondral allografts after clinical transplantation. J Bone Joint Surg Am 1990; 72:574–581

Friedlander GE, Horowitz MC. Immune responses to osteochondral allografts: nature and significance. Orthopedics 1992; 15:1171–1175

Garrett JC. Fresh osteochondral allografts for the treatment of articular defects in osteochondritis dissecans of the lateral femoral condyle in adults. Clin Orthop 1994; 303:33–37

Hangody L, Karpati Z. New possibilities in the management of severe circumscribed cartilage damage in the knee. Magyar Traumatologia, Ortopedia, Kezsebeszet, Plasztikai Sebeszet 1994; 37:237–243

Mankin HJ. The response of articular cartilage to mechanical injury. J Bone Joint Surg Am 1982; 64:460–466.

Meyers MH, Akeson W, Convery FR. Resurfacing of the knee with fresh osteochondral allograft. J Bone Joint Surg Am 1989; 71:704–713

Open Fractures of the Shaft of the Tibia

OPEN FRACTURES OF the shafts of the tibia and fibula continue to challenge orthopedic, vascular, trauma, and plastic surgeons, because these are the most common and serious of open fractures. They are commonly due to high-energy trauma such as that which occurs in motor vehicle accidents, when pedestrians are hit by vehicles, or in high-velocity falls or sports injuries. Although the bone injury can be challenging to the orthopedic surgeon, it is the severity of injury to the soft tissue envelope that determines the prognosis and drives the decision-making process regarding treatment. Because of advances in vascular repair, bone fixation, bone grafting techniques, and local and free microvascular flaps, we are now able to salvage limbs that were previously not salvageable. Salvage of the mutilated leg can require multiple operations over two years or more. Even with these conditions in place, the patient can be left with a disabled extremity that is less functional than a below-the-knee prosthesis, particularly if the foot is severely disabled or if there is a residual paralysis of the muscles served by the common peroneal and/or posterior tibial nerves.

Most agree that there are two absolute indications for immediate amputation in severe open tibial fractures associated with a vascular injury that would require repair for the limb to survive: a crush injury with a warm ischemia time of more than 6 hours and a transection of the tibial nerve. There are several relative indications for amputation, including serious associated polytrauma, severe ipsilateral foot injuries, or an anticipated protracted course of treatment that is not socioeconomically sustainable.

The basic goals in treating open fractures of the tibia are to avoid infection, achieve early soft tissue closure, provide immediate bone stabilization that permits healing in the most anatomical position possible, and restore function early. The most important of these is the prevention of infection, because if infection and osteomyelitis occur, it becomes exceedingly difficult to achieve the other goals. In the emergency department environment, open fractures—particularly those with

contaminated large open wounds—benefit from immediate irrigation of the site with sterile saline (either poured from a bottle or administered with a pulsatile irrigation system) and removal of any gross debris. A compressive dressing should then be applied; this can be soaked in a dilute solution of Povidine if formal surgical debridement will be delayed. The fracture should be reduced, if possible, and then immobilized in a long-leg, well-padded splint. Intravenous antibiotics should be administered as soon as possible. One gram of Cefazolin intravenously every 8 hours suffices for most open fractures. Penicillin and an aminoglycoside may be necessary as well in highly contaminated fractures—particularly those that occurred in an agricultural setting, where there is a high risk of clostridial infection. A careful assessment of neurovascular function is essential. Because compartment syndrome can occur in open fractures, this assessment includes an essential search for compartment syndrome and measurement of compartment pressures (if indicated). The patient should be taken to surgery as soon as possible, where a meticulous layer-by-layer debridement and pulsatile irrigation must be accomplished. It is safest to leave the wounds open and perform delayed primary closure. There is evidence to suggest the utility of implanting polymethylmethacrylate beads that are impregnated with antibiotics and covered with an oxygen permeable membrane. Doing so may reduce the infection rate and protect tissues sensitive to dehydration.

The fracture immobilization method of choice involves inserting an unreamed locked intramedullary nail. Gently using one or two reamers to enable the placement of a larger nail with stronger cross-locking screws is also acceptable. In fracture patterns where intramedullary nailing is not practical, external fixation is the appropriate treatment

As soon as the wound is free of necrotic tissue and any evidence of infection, closure should be performed—with local or free full-thickness flaps if necessary. In cases of severe open fractures, delayed union or nonunion of the fracture is common. In cases in which there has been extensive soft tissue stripping or bone loss, early grafting with autologous cancellous bone may hasten the rate of union and reduce the incidence of a nonunion. This grafting is usually performed after the soft tissue envelope has recovered from the injury, between 6 and 12 weeks after the injury. Using current techniques, acute infection rates vary from 3% to 7%, with union rates of 98% to 100%. Recent studies have shown that late osteomyelitis rates continue to approach zero.

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REFERENCES

Tomena P III, Bergman M, Watnik N, Berkowitz G, Steuer J. Treatment of grade III-B open tibial fractures. J Bone Joint Surg 1994. 76B13

Lumbar Interbody Fusion Utilizing Fusion Cages

LOW BACK PAIN is the most common musculoskeletal complaint reported to physicians by their patients. At one time or another, 95% of the general population will experience significant low back pain. Fortunately, 95% of these patients improve within three months of presentation. The majority of the dollars used to treat low back pain is spent on the remaining 5%. Low back pain remains the largest source of disability in the working population.

Despite its pervasiveness and significant sociological impact, identifying the source of low back pain remains elusive. In fact, of those patients presenting with low back pain, only 15% will be accurately diagnosed. Many authors believe that the source of the pain is the disc itself. The disc can either undergo painful degeneration or become acutely injured. Injury to the disc itself is commonly referred to as internal disc disruption.

In patients who remain symptomatic despite an aggressive conservative care program, surgical treatment may become an option. Many spinal surgeons advocate lumbar fusion for the treatment of unremitting low back pain that has been refractory to aggressive conservative care. Many fusion techniques (posterior, posterolateral, or interbody) and approaches (anterior, posterior, or both) are available.

Many believe that interbody fusion (fusion between the vertebral bodies) offers a number of advantages to posterior interlaminar or posterolateral intertransverse process fusion. The cancellous bone of the vertebral body provides an excellent fusion bed, as opposed to the surgically traumatized posterior paraspinal musculature. Interbody fusion allows the disc space to be both evacuated and distracted. Distraction allows the neural foramen to be enlarged, eliminating any foraminal stenosis that might be present secondary to degenerative loss of disc height. Interbody fusion can be accomplished by either an anterior or a posterior approach. Autografts or allografts can be a number of shapes (dowels, blocks, rings, or chips).

In an attempt to improve stability, expedite the rate of fusions and recovery, and improve patient function, interbody devices have been developed. The precursor to these implants was the "Bagby Basket," designed to treat a form of cervical instability known as "Wobbler Syndrome" in horses; this technology was modified for human use in the mid-1980s. These devices consist of threaded, perforated titanium cylinders. Another device currently in clinical trials is a carbon fiber rectangular cage. This cage is packed with bone graft and inserted between the vertebral bodies through either an anterior or a posterior approach. The anterior approach can be either retroperitoneal or laparoscopic. The laparoscopic approach can be quite challenging at the L4–5 level because of the overlying vascular structures, but quite feasible at the L5–S1 level.